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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : A61F 5/58, G10L 3/02 — A1

(11) International Publication Number: WO 94/00085

(43) International Publication Date: 6 January 1994 (06.01.94)

(21) International Application Number: PCT/CA93/00159

(22) International Filing Date: 20 April 1993 (20.04.93)

(30) Priority data:
P-294965 19 June 1992 (19.06.92) PL

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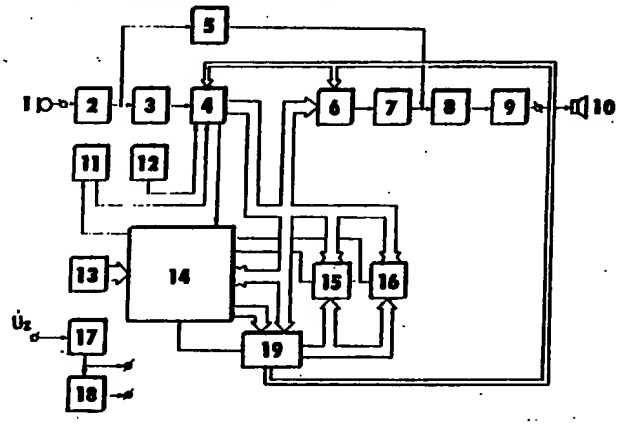
(81) Designated States: AT, AU, BB, BG, BR, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD AND ELECTRONIC SYSTEM OF THE DIGITAL CORRECTOR OF SPEECH FOR STUTTERING PEOPLE



(57) Abstract The invention is solving the subject of the design of the method of digital correction of speech and of the microprocessor-based active speech corrector for stuttering people. Type of digital correction of speech for stuttering people, through electronic signal processing in acoustical feedback loop is characteristic in this, that acoustical signal obtained from the stuttering person via microphone or contact microphone is divided into two frequency bands, from which higher bandwidth is passed in analog domain after amplification to the output electroacoustic transducer, and lower bandwidth is sampled and processed with analog-to-digital converter. Sampled signal obtained in this fashion is processed digitally via tone shifting downwards and simultaneously delayed with regulation of loudness. Processed in this fashion lower bandwidth of frequencies is next mixed with high-pass analog signal and as output signal is sent to electroacoustic transducer, for example earphones or bone vibrator. The invention includes also the electronic digital processor used for the implementation of the above algorithms. The processor configuration is presented in the figure. List of symbols used in the figure is as follows: (1) electroacoustic input transducer in particular microphone or contact microphone; (2) input amplifier; (3) low-pass filter; (4) analog-to-digital converter; (5) regulator of the output signals amplification level; (6) digital-to-analog convertor; (7) low-pass reconstruction filter; (8) gain regulator of the output signal; (9) output amplifier; (10) output electroacoustic transducer in particular earphone or bone vibrator; (11) sampling circuitry of the analog-to-digital converter; (12) buffer memory of the analog-to-digital converter; (13) block of multi-section programming sequence switch of the microprocessor; (14) microprocessor; (15) programmable memory of the microprocessor; (16) operating memory of the microprocessor; (17) voltage converter of the supply voltage; (18) voltage inverter of the supply voltage; (19) address decoder for the microprocessor; (Uz) supply voltage for the circuit.

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Method and Electronic System of the Digital Corrector of Speech for Stuttering People

Description of the Invention

1. Technology domain

The basis of the invention is the method and electronic system of the Digital Corrector of Speech for stuttering people. The invention is concerned with the structure of the small electronic, digital systems for processing of the acoustical signals for the therapy of the speech disorders, in particular for the stuttering people, for the use in various everyday situations.

The method stems from psychoacoustics of hearing and speech production and the device design is based on the domain of digital electronics.

2. Present state of technology

There are known numerous solutions for the speech correctors in which analog processing circuitry is used for processing of the acoustical signal.

It is known from the Russian patent description No. 66.680 the solution for the electronic echo-corrector of speech, which contains linked in series: microphone, input amplifier, system for echo generation, output amplifier and electroacoustic transducer in the form of the headphones. In the system, according to this invention especially structured subsystem for the generation of the echo is used, which is build from twenty linked in series inductor-capacitor blocks with individual correcting amplifiers. This system accomplishes the delay of the speech signal at discrete values in the range from 0 to 120 ms. The necessity of usage in this system large quantity of inductor-capacitor-based filters and also passive intermediate elements leads to non-uniform transfer characteristics at various values of delay coefficient. Device based on this Russian invention does not qualify for miniaturization and digitalization.

It is also known and used commercially solution of the echo-reverberator speech correctors for stutterers according to the Polish patent description No. 130.362. This device contains known microphone linked with input of known input amplifier, output of which is connected to input of known echo and reverberation circuit with output amplifier and speaker. Important in this invention is, that circuit for generation of echo and reverberation contains input low-pass filter, which is connected with analog-to-digital converter, which is connected with binary shift register, and it in turn is connected with digital-to-analog converter, connected via output of low-pass filter with output of amplifier. In this circuit it is important, that control input of the binary shift register and clock input of the analog-to-digital converter are connected with clock generator with regulated frequency. The input of the input amplifier and output of the output amplifier are connected with telephone antilocal splitting system, which allows for the connection with the local, public telephone network.

Described system of the echo-reverberator speech corrector, although fulfills well its assumptions and qualifies for the miniaturization necessary for device carried by the user, exhibits fault, which is a small effectiveness for correcting speech disorders, such as deep breakage in the speech production or interference in the speech production caused by organic disorders of the hearing.

3. Revealing of the invention

The invention solves the subject of a new type of the speech correction method and a new type of the construction of the speech corrector, not showing the drawbacks of the known solution and allows for the correction of the speech fluency of the patient without masking of the acoustical signal of his speech and acoustical background signals, and it allows also for successful audiological treatment of the numerous speech disorders without neurosurgical intervention. The device may be used in various situations in every day living by the stuttering person. Characteristic for the device is, that it could be used continuously by the stuttering person, who carries it.

Method of digital correction of speech for the stuttering people, through electronic signal processing in acoustical feedback loop, is characteristic in this according to the invention, that acoustical signal obtained from the stuttering person via microphone or contact microphone is splitted into two frequency bands, from which bandwidth with higher frequencies (for example higher than 4000 Hz) is passed in analog domain after amplification to the output electroacoustic transducer, and bandwidth with frequencies lower then for example 4000 Hz is sampled and processed with analog-to-digital converter with regulated sampling frequency typically being not lower then 8 kHz and with resolution not lower then 8 bit. Signal obtained in this fashion is digitally via tone shifting downwards, particularly by 1 or 3/4 or 1/2 or 1/4 octave or upwards by 1/4 or 1/2 octave, and simultaneously delayed from 0 to 250 ms, particularly delay discreetly switchable for example in sixteen steps. Processed in this fashion lower bandwidth of frequencies is next mixed with high-pass analog signal and as an output signal is regulated as to the amplitude and is sent to the electroacoustic transducer, for example headphones or bone vibrator.

Optional modification of the method according to the invention is, that from the lower frequency bandwidth one extracts through known digital filtering algorithms the vocal tone of the speech signal, and transposes its spectrum via shift in frequency or inversion of the phase or delay and next use it for the resynthesis of the speech signal with changed vocal tone.

Another modification of the algorithm uses a procedure for the automatic triggering the lower frequency band processing when the input signal delivered by the transducer is sufficiently high in amplitude. Thus, the signal processing procedures are executed only in the case of speech production by the stutterer, otherwise the signal remains unaffected by any of the processing procedures and is not transmitted by the signal processing channel. The threshold of the digital signal processing channel triggering is selected using the multiple switch built-in to the device.

Proposed digital system for correction of speech for the stuttering people, containing known microphone and amplifier combined with electronic system for signal processing connected to headphone or bone vibrator, is characteristic by this in the invention, that electroacoustic transducer,

particularly microphone or contact microphone is connected via linked in series input amplifier and low-pass filter to analog signal input of analog-to-digital converter working in conjunction with sampling circuitry and buffer memory, and having control input connected to the microprocessor, equipped in input multi-section switch for programming sequences.

Thanks to application in the circuit according to the invention of the microprocessor combined with the input analog-to-digital convertor and output digital-to-analog convertor, it is possible to process digital samples of the speech with the microprocessor. In particular, processing is performed on the lower part of the frequency band, limited for example to 4000 Hz, while the higher band above this frequency is passed without change. Because of the fact, that it is possible to choose various work programs of the device, and also regulation of the volume by the patient, it allows very comfortable use of the device and adjustment of its parameters to actual needs of the patient. Programs for sound processing which are performed via microprocessor system include in particular: regulated frequency transposition (shift in frequency scale) upward or downward, regulated sound delay in the range from 0 to 250 ms, extraction of vocal tone and its resynthesis, phase inversion of the signal in chosen frequency bands, reduction of the level of self-hearing of the vocal tone via phase inversion and shift in time. The mentioned program functions may be selected through the use of the built-in multiple switch (dip switch).

4. Description of figure

The invention is described in detail in the example of its electronic implementation and is illustrated on the drawing introducing simplified block diagram for the digital speech corrector presented in Figure 1.

The illustrated on the drawing circuit of the digital speech corrector works as follows: basic function of shifting in the frequency band with simultaneous delay of the signal in the acoustical feedback path from microphone 1 to earphones 10 is accomplished in following manner, that signal from the input transducer 1 is relayed to input amplifier 2 and after amplification is filtered by low-pass filter 3. Non-filtered high-band

portion of the acoustical input signal is relayed via regulator 5 to output amplifier 9 via level regulator 8, and then to output electroacoustic transducer 10. Signal in the frequency band lower then 4000 Hz is processed by the analog-to-digital converter 4 containing sampling circuitry 11 and individual buffer memory 12. Digital signal is read by the microprocessor 14 from the signal output of the analog-to-digital converter 4, and next it is processed according to the program chosen by the user with the multi-section switch (dip switch) 13. Used in the circuitry block of multi-section switch 13 is in practice eight-section switch of the DIP type, used during the operation of the device to choose one of many programing operations. State of this switch is continuously read by the microprocessor 14. Signal is shifted up or down in the spectrum as it is described in the method. Samples of the signal are stored in the operating memory 16 of the RAM type. Buffering of the samples is important because of the realization of algorithms for signal processing. Set of programs for correction of various types of speech disorders is stored in the ROM-type memory (EPROM) 15. Applied in the circuitry according to the invention address decoder 19 allows for decoding of the memory addresses and analog-to-digital converter addresses. After processing in built in such a way microprocessor system, samples of the acoustical signal in low frequency bandwidth are converted to analog signal via digital-to-analog converter 6. Obtained in this fashion signal with changed frequency spectrum and delayed in time goes to low-pass filter 7, where is smoothed (not needed components are removed). Output amplifier 9 after mixing signals together, amplifies obtained in such a way signal, as to be able to drive output electroacoustic transducer 10 (for example earphones). Source of the power is the rechargeable battery Uz, of which voltage is converted to stable supply voltage in the circuit 17 and via voltage inversion in circuit 18 to the negative supply voltage.

In another implementation of the device it is possible to combine circuits 4, 11, 12, 14, 19, 15, 16, 6 in common signal processing block (circuit, chip).

5. The best way to produce the invention

The electronic circuitry may be produced using the modern automated technology. Main elements of the device should be placed in one electronic chip using the ASIC chip production technique. The chip as well as the remaining electronic elements should be prepared for the surface mounting and should be placed on the single small electronic printed board. The DIP switch (13) and the potentiometers (5) and (8) as in the fig. 1 and small microphone or small socket for contact transducer and small socket for the headphone should be mounted also to this board. The electronic board should be placed in the small plastic casing together with miniature accumulator batteries. The casing have to be designed in such a way that the potentiometers, DIP switch and sockets are to be available to the user without opening the casing.

The device may be carried by the user in a shirt pocket or in the case of further miniaturization may be placed behind his ear. The input and output transducers should be connected to the device using flexible thin cables with small plugs.

6. Industrial application

The device may be a subject to the electronic automated lot production. The plastic casing production may be also automatic using the injection moulding machines. The process of the testing of the device based on the computer measurement arrangement and may be also performed automatically.

Method and Electronic System of the Digital Corrector of Speech for Stuttering People

Patent Claims

1. Type of digital correction of speech for stuttering people, through electronic signal processing in acoustical feedback loop, characteristic in this according to the invention, that acoustical signal obtained from the stuttering person via known microphone or contact microphone is divided into two frequency bands, from which bandwidth with frequencies not lower then for example 4000 Hz is passed in analog domain after amplification to the output electroacoustic transducer, and signal in bandwidth with frequencies lower then for example 4000 Hz is triggered and then sampled and processed with analog-to-digital convertor, sampled and quantized signal obtained in this fashion is processed digitally via tone shifting downwards, particularly by 1 or 3/4 or 1/2 or 1/4 octave or upwards by 1/4 or 1/2 octave and simultaneously delayed from 0 to 250 ms, particularly delay discreetly switchable for example in sixteen steps, with simultaneous regulation of loudness and processed in this fashion bandwidth of frequencies lower then 4000 Hz is next mixed with high-pass analog signal and as output signal is sent to electroacoustic transducer, for example earphones or bone vibrator.

2. Method according to claim 1 characteristic in this, that from bandwidth with frequencies lower then for example 4000 Hz one extracts through digital filtering algorithms vocal tone of the speech signal, and transposes its spectrum via shift in frequency or inversion of the phase or delay and next use it for resynthesis of the speech signal with changed vocal tone.

3. Circuit for the digital speech corrector for stuttering people including microphone and amplifier combined with signal processing electronic circuitry connected to earphone or bone-vibrator characteristic in this, that known input electroacoustic transducer, in particular microphone or contact microphone signal from the input transducer 1 is relayed to input amplifier 2 and after amplification is filtered by low-pass filter 3, when non-filtered high-band portion of the acoustical input signal is relayed via regulator 5 to output amplifier 9 via level regulator 8, and then to output

electroacoustic transducer 10. Filtered by the low-pass filter 3 signal in the frequency lower band is processed by the analog-to-digital converter 4 containing sampling circuitry 11 and individual buffer memory 12 and produced in such a way digital signal is read by the microprocessor 14 from the signal output of the analog-to-digital converter 4, and next it is processed according to the program chosen by the user with the multi-section switch (dip switch) 13 state of which is continuously read by the microprocessor 14. Processed signal is shifted up or down in the spectrum as it is described in the method. Samples of the signal are stored in the operating memory 16 of the RAM type. Set of programs for correction of various types of speech disorders is stored in the ROM-type memory (EPROM) 15. Applied in the circuitry according to the invention address decoder 19 allows for decoding of the memory addresses and analog-to-digital converter addresses. After processing in built in such a way microprocessor system, samples of the acoustical signal in lower frequency bandwidth are converted to analog signal via digital-to-analog converter 6. Obtained in this fashion signal with changed frequency spectrum and delayed in time goes to low-pass filter 7, where is smoothed (not needed components are removed). Output amplifier 9 after mixing signals together, amplifies obtained in such a way signal, as to be able to drive output electroacoustic transducer 10 (for example earphones). Source of the power is the rechargeable battery Uz, of which voltage is converted to stable supply voltage in the circuit 17 and via voltage inversion in circuit 18 to the negative supply voltage.

4. Circuitry according to Claim 3, characteristic in this, that microprocessor is connected with two identical buses for digital-to-analog conversion of the acoustical signal, appropriately to the left ear and to the right ear, connected to one common input electroacoustic transducer, and having individual output electroacoustic transducers.

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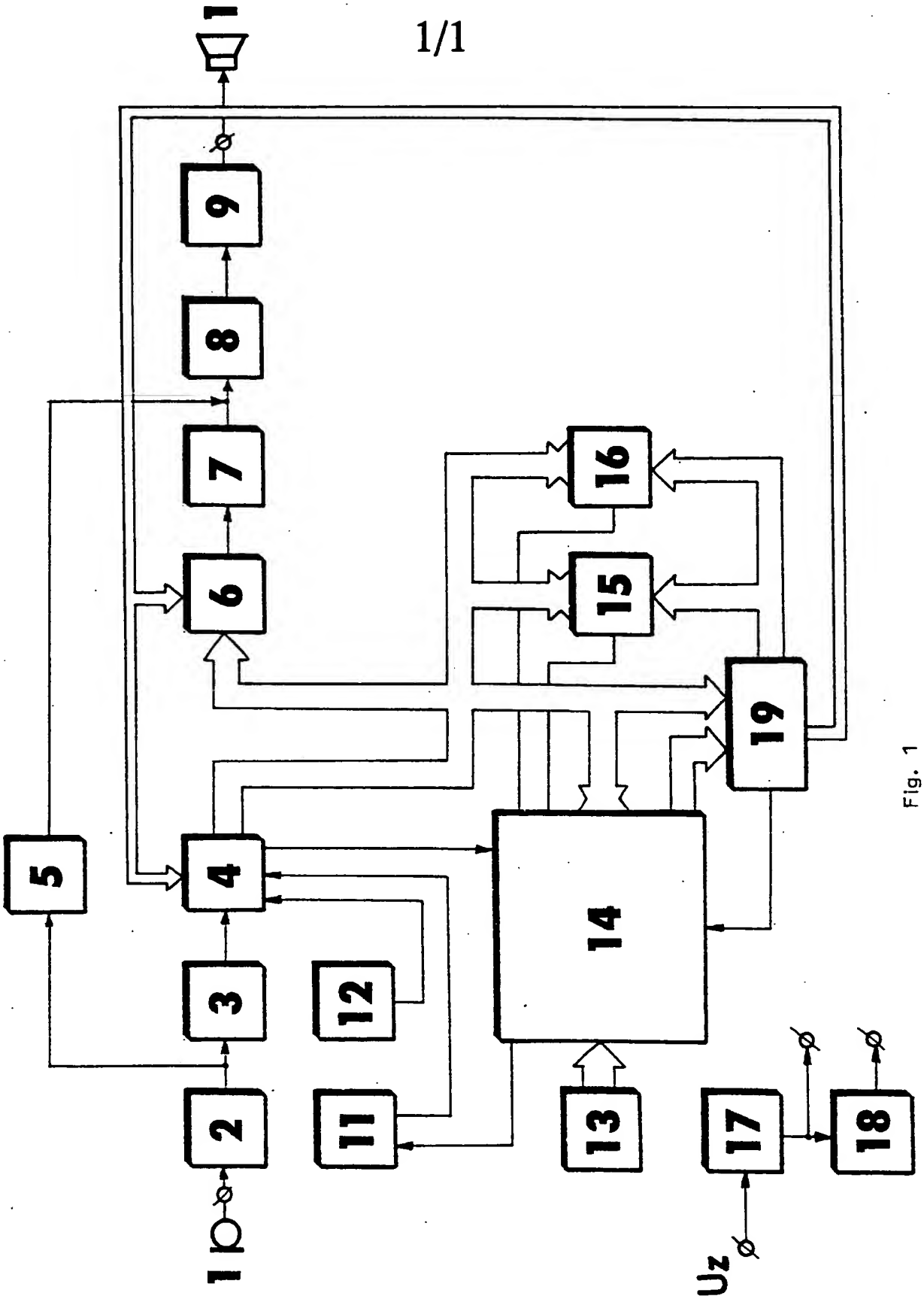

Fig. 1

INTERNATIONAL SEARCH REPORT

International Application No PCT/CA 93/00159

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 A61F5/58; G10L3/02

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	A61F ; G10L

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	US,A,4 464 119 (VILDGRUBE) 7 August 1984 see column 2, line 23 - line 66 see claims 1,2	1-4
A	US,A,4 051 331 (STRONG) 27 September 1977 see abstract see claims 1-6	2

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US-A-4464119	07-08-84	None	
US-A-4051331	27-09-77	None	